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(54) Method and means for aligning a rock drill

(57) A method for automatically aligning the drill stem 4 and bit 5 of a rock drill rig when the applied feeding power on the drilling machine 3 has resulted in deformation of the articulated and extensible drill boom 1 of the rig and of its pivotally supported drill support 2 on the drill boom 1, the drill rig being of the type that comprises elements 9, 10 for measuring boom lengths and articulation angles, comprises servo means (11) for controlling said lengths and angles and a control unit 15 which is connected to the measuring elements and servo means for adjusting the drill stem 4 and bit 5. The various articulation angles to compensate for deformations are determined as if the drill boom and support were in an unloaded condition. Further, the adjusted articulation angles are corrected to the determined articulation angles when full feeding power is applied.

ERRATUM

SPECIFICATION No. 2 103 969 A

At the bottom of front page insert The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

THE PATENT OFFICE
6th April, 1983

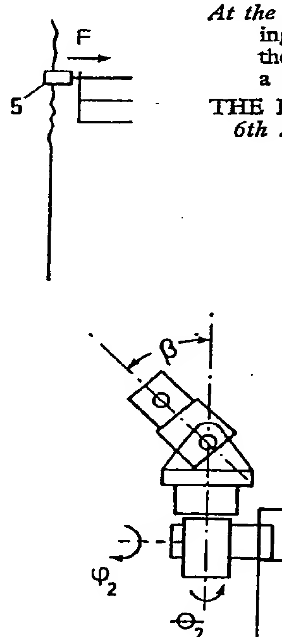

Fig. 2

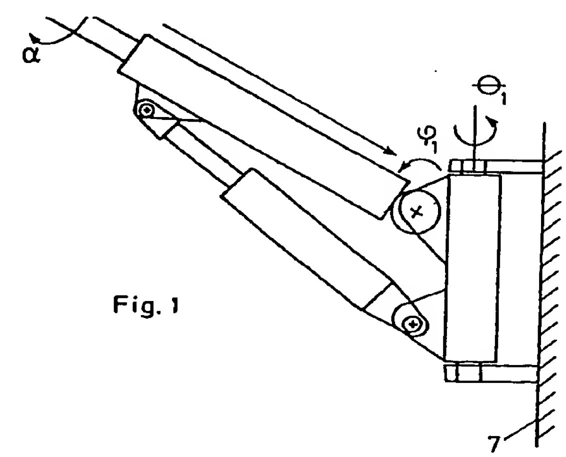

Fig. 1

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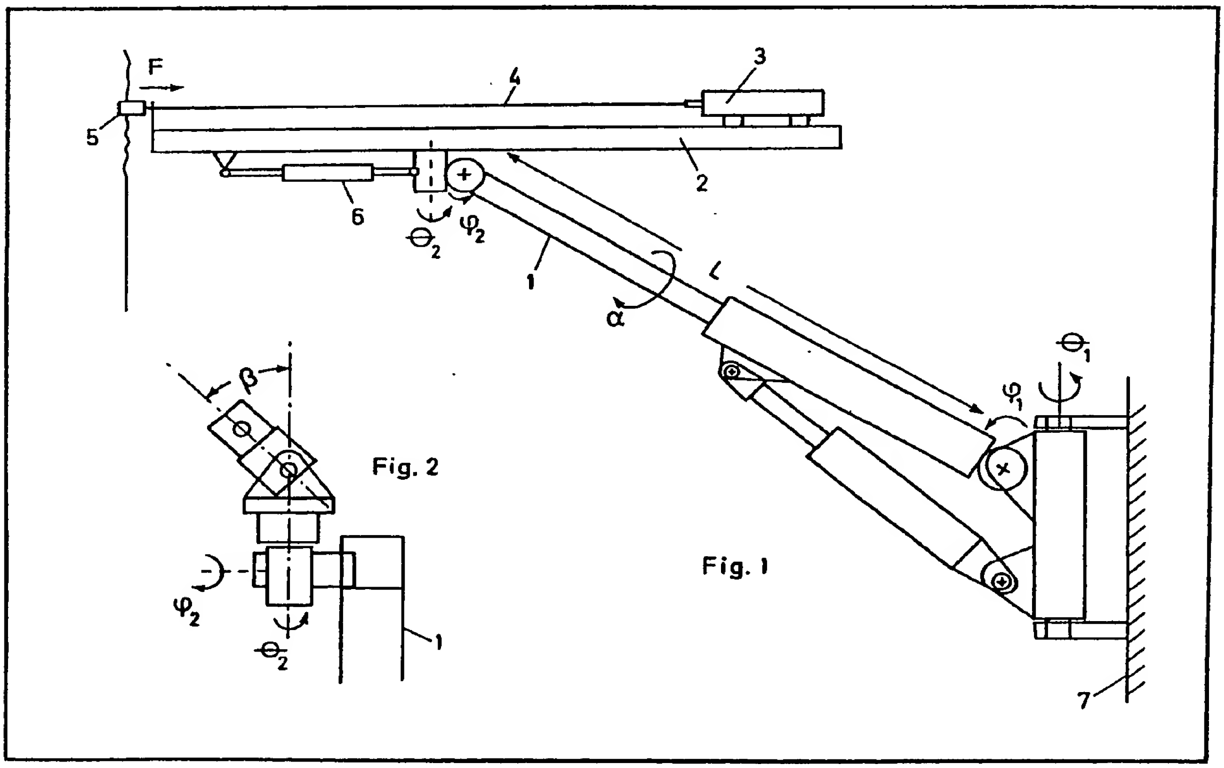

Fig. 2

Fig. 1

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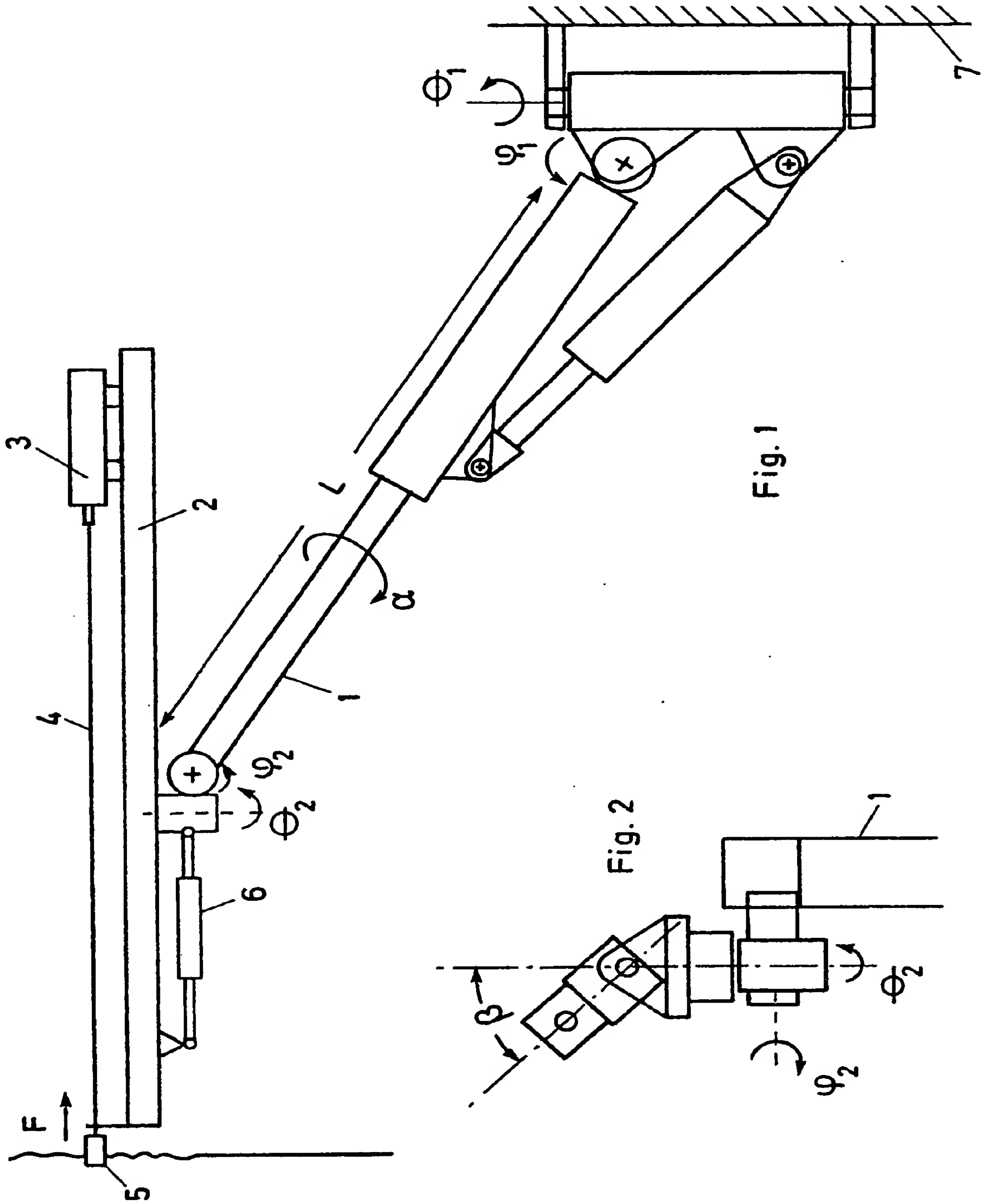

Fig. 1

Fig. 2

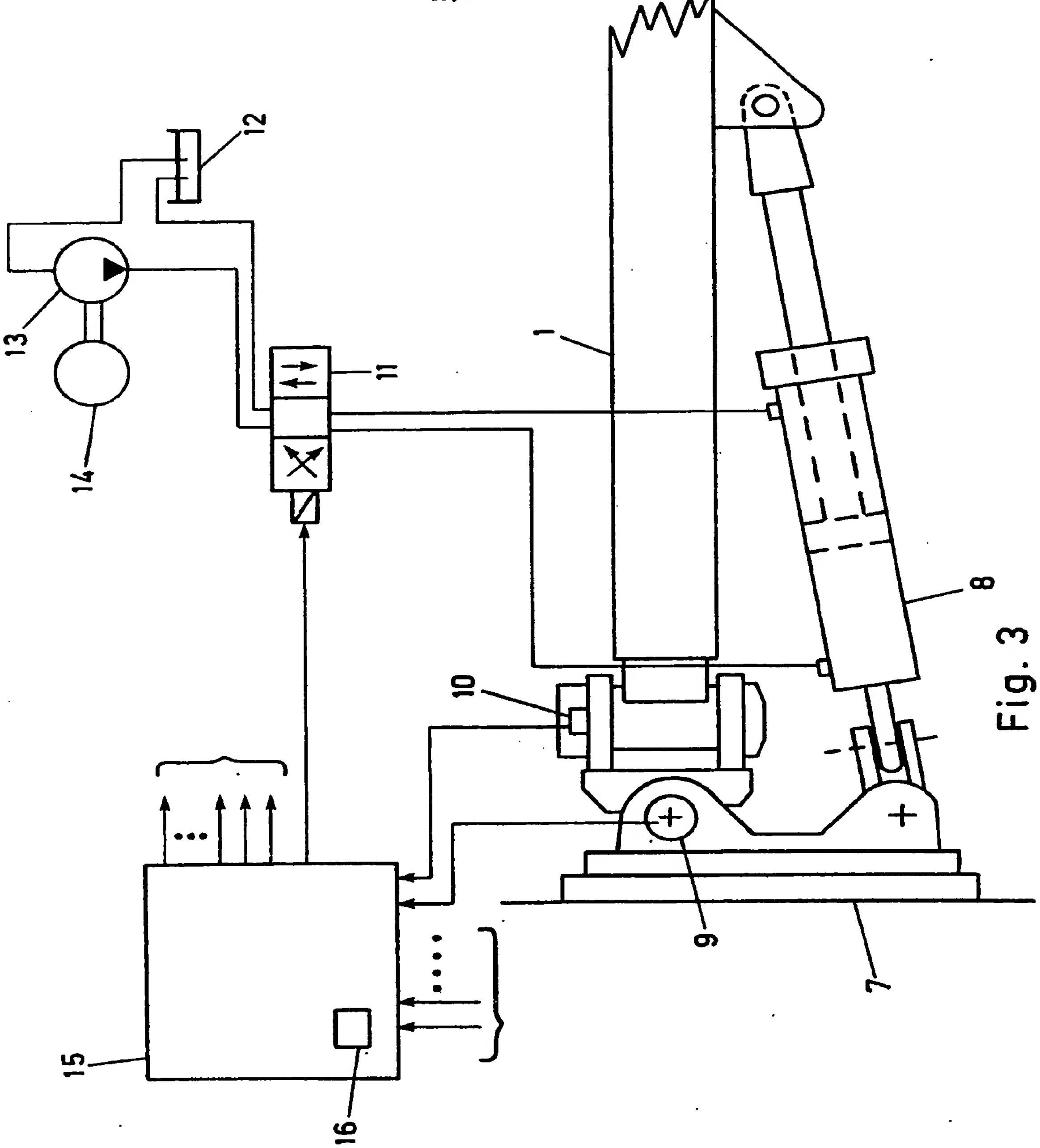

Fig. 3

SPECIFICATION
Method and means for aligning a rock drill

The present invention relates to a method for aligning the drill stem and bit of a rock drill rig when the drilling procedure starts. Further, the invention relates to a means for performing said method.

When drilling holes in rock for blasting or other purposes it is important that each hole gets a correct direction. However, the hole may obtain a wrong direction even if the drill stem has been correctly adjusted before the drilling procedure starts. Such faulty drilling has mainly two causes. On one hand, this faulty drilling may happen because the drill stem and bit are pushed against the rock at such a high feeding power that the articulated and extensible drill boom as well as the pivotally supported feed support of the rock drill rig, are bent or deformed with the result that the drill stem and bit are forced into a wrong direction. On the other hand, the drill bit may slip sideways along an uneven rock surface and thus bring the drill step out of its correct direction. In addition to getting an incorrect direction the drill stem may in both cases be exposed to bend which will reduce its lifetime.

Due to the practical geometry of the drill boom a perfect correction of the direction of the drill stem and bit requires adjustment on preferably all axises of the boom. This correction is performed manually today, and is often measured by sight. Possible instrumentation in this connection has hitherto been limited to a means that shows the direction of the feed support. Manual adjustment of the drill, with or without such a means, is a difficult operation and the result is to a great extent dependent on the ability and attention of the operator. When drilling the peripheral holes in particular, high requirements are set to the operator because the direction of the drill stem is then especially important since these holes determine the shape of the blasted cavity.

When the drill stem has been forced in a wrong direction, the operator of today has to adjust the stem by sighting from the operator's seat on the drill rig. In many situations when drilling in tunnels, however, visual observation of the direction and of the bend of the drill stem is almost impossible because the sight is hindered from the drill boom and support.

When having a good procedure for setting of the drill against the rock surface, the number of events when the drill bit slips during setting, is considerably reduced.

The invention provides a method for aligning the drill stem and bit of a rock drill rig when drilling starts and the applied feeding power on the drilling machine of the rig has resulted in that an adjusted direction of the drill stem has changed because of deformation of the articulated and extensible drill boom of the rig and of its pivotally supported drill support on the drill boom, which drill rig comprises elements for measuring boom lengths and articulation angles, servo means for controlling said lengths and angles and a control unit which is connected to the measuring elements and servo means for adjusting the drill stem and bit, in which method the adjusted articulation angles which are required to compensate for deformations of the drill boom and drill support are determined as if the drill boom and support were in a loaded condition, on the basis of measured valves of the boom lengths and articulation angles which have been registered in the control unit in an unloaded adjusted condition, and in which method the adjusted articulation angles are corrected when full feeding power is applied, to the articulation angles having been determined, whereby the drill stem and bit get a correct position and direction in the loaded condition as well.

The invention also provides means for performing the method during operation of an automatically controlled drill rig, including a control unit which comprises a computer, which computer includes a mathematic model with a definition of the changes of the articulation angles.

A preferred example of the invention will now be described with reference to the accompanying drawings, wherein

Figure 1 diagrammatically shows the drill boom and drill support with drill stem and bit of a rock drill rig,

Figure 2 shows a detail in figure 1, and

Figure 3 shows the drill boom in figure 1 in a coupling with a control system.

In figure 1 is shown an articulated and extensible drill boom 1 which carries a pivotally supported drill support 2 with a drilling machine 3, drill stem 4 and bit 5. The drill support 2 is moved forward and backwards by means of a hydraulic cylinder 6. The drill boom 1 is fixed to a drill rig at a supporting location 7. The drill rig is of the type which is used for drilling and blasting tunnels in rocks.

The drill boom 1 can be turned horizontally an angle θ_1, and vertically an angle Φ_1. Additionally, the boom 1 may be rotated an angle α in relation to its rear end support 7 on the rig. The length L of the boom 1 can be adjusted, and the length can be measured by means of any suitable measuring element of a previously known type. Likewise, the drill support 2 can be turned the angles θ_2 and Φ_2 about two axises which are vertically positioned on each other. Additionally, the drill support 2 may be rotated an angle β around an axis which is parallel to the support 2, as indicated in figure 2.

The drill boom 1 and drill support 2 are equipped with previously known elements for measuring boom lengths and articulation angles, and the rig comprises servo means for controlling the lengths and angles, as indicated in figure 3. Further, the rig is equipped with a control unit in a previously known manner, which unit is connected to the measuring elements and servo means for adjusting and feeding the drill stem 4,

and which can control a number of drill booms 1 and drill supports 2.

In figure 3 is shown a portion of the drill boom 1 in its support 7. The boom 1 can be moved by means of a hydraulic cylinder 8 which has been shown apparent in figure 1 as well. In figure 3 is indicated an element 9 for the measurement of the angle Φ_1, and an element 10 for the measurement of the angle θ_1. Corresponding elements for measuring the remaining angles are omitted for not overloading the drawings. For the sake of simplicity only one servo means is shown, namely the servo valve 11 for adjusting among other values, the angle Φ_1 by means of the hydraulic cylinder 8. The servo valve 11 is connected to an oil tank 12 and a hydraulic pump 13 being driven by a motor 14.

Electrical signals from at least the angle sensors or elements 9 and 10 reach an electronic control unit 15 as indicated with arrows and spots. From the control unit 15 electrical signals are supplied to among other means, the servo valve 11 as indicated. All measuring elements and servo means are connected to the control unit 15 which may be in the form of one or more microprocessors.

When the drill bit 5 is pushed against the rock with a feeding power F on the drill stem 4, the drill support 2 is bent from the bending moment between the force in the drill stem 4 and in the cylinder 6. This bend or deformation of the drill support 2 will occur in a plane through the drill stem 4 and cylinder 6. This deformation may be compensated for by correcting changing the angles Φ_2 and θ_2, thus:

$$\Delta\Phi_{21}=K_3 \cdot F \cdot \cos\beta$$
$$\Delta\theta_{21}=K_3 \cdot F \cdot \sin\beta$$

wherein K_3 is an experimentally adapted rigidity constant for the boom 2. For the feeding power F a measured or assumed typical value may be used.

Additionally, the supplied feeding power will cause a bend or deformation of the drill boom 1. The present bending moment is proportional to the feeding power F and the projection of the boom 1 in a plane which is right angled on the drill stem 4. The deformation of the boom 1 may be compensated for in the following two ways:

1) Φ_1 and θ_1 are corrected or changed such that the axises of the angles Φ_2 and θ_2 become located in the same positions in space after the boom 1 was bend, as they were before i was bend, thus:

$$\Delta\Phi_1=K_1 \cdot L \cdot F \cdot (\sin\Phi_2 \cdot \cos\alpha+\sin\theta_2 \cdot \sin\alpha)$$
$$\Delta\theta_1=K_1 \cdot L \cdot F \cdot (\sin\theta_2 \cdot \cos\alpha+\sin\Phi_2 \cdot \sin\alpha)$$

wherein K_1 is an experimentally adapted rigidity constant for the boom 1.

2) Φ_2 and θ_2 are corrected or changed such that the direction of the drill support 2 becomes the same even if the front or outermost end of the boom 1 has changed direction because of the deformation, thus:

$$\Delta\Phi_{22}=K_2 \cdot L \cdot F \cdot \sin\Phi_2$$
$$\Delta\theta_{22}=K_2 \cdot L \cdot F \cdot \sin\theta_2$$

wherein K_2 is an experimentally adapted rigidity constant for the boom 1.

Thus, the total correction becomes:

for

$$\Delta\Phi_2,\ \Delta\Phi_2=\Delta\Phi_{21}+\Delta\Phi_{22}$$

and for

$$\Delta\theta_2,\ \Delta\theta_2=\Delta\theta_{21}+\Delta\theta_{22}$$

In a preferred embodiment of the invention a simplified mathematical model of the geometry and rigidity of the drill boom 1 and drill support 2 has been realized in accordance with the considerations described above, as follows:

$$\Delta\Phi_1=K_1 \cdot L \cdot F \cdot (\sin\Phi_2 \cdot \cos\alpha+\sin\theta_2 \cdot \sin\alpha)$$
$$\Delta\theta_1=K_1 \cdot L \cdot F \cdot (\sin\theta_2 \cdot \cos\alpha+\sin\Phi_2 \cdot \sin\alpha)$$
$$\Delta\Phi_2=K_3 \cdot F \cdot \cos\beta+K_2 \cdot L \cdot F \cdot \sin\Phi_2$$
$$\Delta\theta_2=K_3 \cdot F \cdot \sin\beta+K_2 \cdot L \cdot F \cdot \sin\theta_2$$

The drill boom 1 is often shaped such that the angles α and β equal zero, whereby the simplified mathematical model from above can be simplified still further.

Briefly, the method comprises the following process steps:—

The drill stem is adjusted in a correct position and direction in an unloaded condition.

In succession to this adjustment the boom lengths and articulation angles are registered in the unloaded condition.

One determines the various boom lengths and articulation angles which are required to compensate for the deformations which the drill boom and drill support will get when being loaded at full feeding power, on the basis of the lengths and angles having been registered.

The adjusted boom lengths and articulation angles are corrected when full feeding power is applied, to the lengths and angles having been determined, whereby the drill stem gets a correct position and direction in the loaded position as well.

The mathematical model according to the invention may be realized physically in the form of one or more microprocessors or other more simple electronic devices 16 which are encompassed by the control unit 15. The fixed values in the mathematical model, such as the formulas for the angle-changes, may be deposited into the components in accordance with known technology. The variable values may be deposited as well in the form of series of eligible values, or they may be programmed in the computer or microprocessor mentioned above.

When using an automatically controlled drill rig it has become apparent that a good procedure for setting of the drill in a start drilling position, may reduce the number of events when the drill bit slips sideways during setting, down to below 10 per cent. In the remaining events the drill may get

a correct alignment in a simple way by means of the method and means having been described herein.

The method described has the advantage of providing effective and precise correction of faults and faulty directions which are due to deformations of the drill boom and drill support because of the feeding power on the drilling machine. Furthermore,, the apparatus described provides automatically performance of the method.

Claims

1. A method for aligning the drill stem and bit of a rock drill rig when drilling starts and the applied feeding power on the drilling machine of the rig has resulted in that an adjusted direction of the drill stem has changed because of deformation of the articulated and extensible drill boom of the rig and of its pivotally supported drill support on the drill boom, which drill rig comprises elements for measuring boom lengths and articulation angles, servo means for controlling said lengths and angles and a control unit which is connected to the measuring elements and servo means for adjusting the drill stem and bit, in which method the adjusted articulation angles which are required to compensate for deformations of the drill boom and drill support are determined as if the drill boom and support were in a loaded condition, on the basis of measured values of the boom lengths and articulation angles which have been registered in the control unit in an unloaded adjusted condition, and in which method the adjusted articulation angles are corrected when full feeding power is applied, to the articulation angles having been determined, whereby the drill stem and bit get a correct position and direction in the loaded condition as well.

2. A method as claimed in claim 1, wherein deformation of the drill support is compensated for by changing the two angles in which the drill support may be turned in relation to the drill boom about the two axises which are vertically positioned on each other, until the direction of the drill stem and bit becomes correct even if the drill support is deformed.

3. A method as claimed in claim 1, wherein deformation of the drill boom is compensated for by changing the two angles in which the drill boom may be turned horizontally and vertically in relation to the drill rig, until the mutual right angled axises of the two angles in which the drill support may be turned in relation to the drill boom, become located in the same positions in space after the drill boom has been deformed, as they were before it was deformed, and wherein deformation of the drill boom is compensated for by changing the two angles in which the drill support may be turned in relation to the drill boom about the two axises which are vertically positioned on each other, until the direction of the feed support becomes correct even if the drill boom is deformed.

4. A means for performing the method as claimed in any of the claims 1 to 3, during operation of an automatically controlled drill rig, including a control unit which comprises a computer, which computer includes a mathematic model with a definition of the changes of the articulation angles.

5. A method for aligning the drill stem and bit of a rock drill rig, substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

6. Apparatus for aligning the drill stem and bit of a rock drill rig, substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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